The cervical spine generally maintains a lordotic curve with a mean lordosis angle of 16–22° in men and 15–25° in women. Kyphotic deformity of the cervical spine can occur due to advanced degenerative disease, trauma, neoplasm, systemic arthritides, and, most commonly, iatrogenic or postsurgical causes.

The cervical spine is more prone to develop kyphosis due to its biomechanical properties. Unlike the thoracic and lumbar vertebrae, the anterior vertebral column of the cervical spine bears only 36% of the load. Thus, the posterior facets are responsible for the majority of the axial load. Kyphosis after a laminectomy, which occurs in as many as 20% of patients, develops due to the loss of the natural posterior tension band. Denervation and atrophy of the posterior cervical muscles and disruption of the facet joints result in increased loads on the anterior column. Once kyphosis develops, the axial load leads to further kyphosis due to a moment-arm-induced bending moment, and thus the saying “kyphosis begets kyphosis.”

There are concerns with kyphotic deformity of the cervical spine that may lead to degenerative changes and kyphotic deformities. The initial decompression of the spinal cord disappears as the cord is stretched over the anterior lesions. Muscle damage and facet degeneration from prior surgery contribute to additional pain, muscle spasm, and motion. Occasionally prior surgical fusion that fails to address the kyphosis or spontaneous fusion in a kyphotic position (observed more in laminectomies performed in the growing spine) can result in a challenging rigid deformity with anterior vertebral body and lateral mass facet fusion. For this fixed deformity, anterior and posterior release are often necessary for restoration of lordosis, which can result in the need for a 540° procedure. In this report the authors describe an anterior technique for simultaneous anterior and posterior lateral mass release. The vertebral artery is mobilized using this technique, allowing for its lateral retraction. The nerve roots are visualized and retracted superiorly and inferiorly. The lateral mass and facets can then be accessed anteriorly using an osteotome or drill for the release. The authors illustrate this technique in a patient who developed fixed scoliosis and kyphosis of the cervical spine after surgery for degenerative disc disease. To the authors’ knowledge, this is the first report of this technique. (DOI: 10.3171/SPI/2008/8/6/594)

Key Words • anterior release • degenerative disc disease • kyphosis • vertebral artery

Abbreviation used in this paper: VA = vertebral artery.

A novel anterior technique for simultaneous single-stage anterior and posterior cervical release for fixed kyphosis

Technical note

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The incidence rate of kyphosis of the cervical spine after a laminectomy can be as high as 20% after a multilevel laminectomy. The loss of the posterior tension band leads to increased load on the vertebral body and discs, leading to further degenerative changes and kyphotic deformities. The initial decompression of the spinal cord disappears as the cord is stretched over the anterior lesions. Muscle damage and facet degeneration from prior surgery contribute to additional pain, muscle spasm, and motion. Occasionally prior surgical fusion that fails to address the kyphosis or spontaneous fusion in a kyphotic position (observed more in laminectomies performed in the growing spine) can result in a challenging rigid deformity with anterior vertebral body and lateral mass facet fusion. For this fixed deformity, anterior and posterior release are often necessary for restoration of lordosis, which can result in the need for a 540° procedure. In this report the authors describe an anterior technique for simultaneous anterior and posterior lateral mass release. The vertebral artery is mobilized using this technique, allowing for its lateral retraction. The nerve roots are visualized and retracted superiorly and inferiorly. The lateral mass and facets can then be accessed anteriorly using an osteotome or drill for the release. The authors illustrate this technique in a patient who developed fixed scoliosis and kyphosis of the cervical spine after surgery for degenerative disc disease. To the authors’ knowledge, this is the first report of this technique. (DOI: 10.3171/SPI/2008/8/6/594)
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deforrrory. For a deformity that is fixed circumferentially with anklyosed facets, both anterior and posterior releases are often needed. This approach requires resection of the lateral vertebral body osteophytes and fusion mass to lengthen the anterior column as well as resection of the facets or posterior fusion mass. This resection is often accomplished through a so-called “540°” approach in which the patient undergoes anterior decompression and release first, followed by posterior decompression, release, fixation, and correction of the deformity. Anterior instrumentation is then placed in the final stage. This approach is necessary when the posterior elements, such as the lateral masses, are fixed and only limited correction can be achieved after anterior release, and thus placement of final instrumentation and grafts is not possible during the first stage.

In the anterior release stage, resection of the lateral vertebral body’s osteophytes and fusion mass may be accomplished in 2 ways with respect to the management of the VA. The first is a relatively blind drilling in which the VA is not identified and a diamond drill is used to slowly drill until soft tissue is reached laterally. The second method, which we favor and have routinely used, is to first directly identify the VA and mobilize it laterally under the transverse process and protect it directly with a Penfield 4 dissector during lateral bone resection. We had noticed in some of our previous anterior osteotomy cases with direct VA visualization and mobilization that it was occasionally possible to access the anterior aspect of the facet joints between the pedicles and nerve roots. In this report, we describe a case in which we were able to use this lateral VA mobilization to take advantage of the anterior access to the facets so we could release the posterior column as well using an anterior approach. In this case we were able to avoid a third-stage procedure, which allows for the greater part of the kyphotic deformity to be corrected anteriorly, and therefore placement of the final anterior cage and instrumentation can be performed during the first stage. It is then followed by a standard posterior fixation to achieve additional stability and further posterior compression for additional correction of the kyphosis and graft loading. We illustrated the technique in a patient who developed kyphotic and scoliotic deformity after anterior cervical discectomy and fusion along with a posterior lateral mass fusion due to degenerative disc diseases.

Case Report

History and Examination. This patient was a 65-year-old female who underwent an anterior cervical discectomy and fusion at the C3–4 level 5 years ago due to degenerative disc disease. She experienced some relief of her neck pain after the surgery, but it worsened over the next 3 years. She then underwent posterior fixation with a lateral mass screw/rod fixation system on the left side at the C2–3 level 2 years ago. During the last 2 years, however, she developed progressive kyphosis and scoliosis of her cervical spine with significant deviation of her head position to the right (Fig. 1). Her motor strength also significantly decreased. During her motor strength examination, her right deltoid, biceps, and triceps motor strength were 1/5, according to the Medical Research Council scale. Her right iliopectos, quadriceps, and hamstrings showed a motor strength of 2/5. She was able to wiggle her right fingers. Her left-side motor strength was 4/5 in all muscle groups tested in the upper and lower extremities. The patient had significant comorbidities including chronic obstructive pulmonary disease, prior stroke and myocardial infarction, and congestive heart failure.

In this case, plain radiography showed a rigid coronal curve of 75° from C-3 to C-5 with an apex at C-3. There was also 75° of fixed kyphosis in the sagittal plane (Fig. 1A and B). A computed tomography scan showed 1.4 mm of anteriolisthesis of C-3 on C-4, and 3 mm of anteriolisthesis of C-4 on C-5. Significant central canal stenosis was observed at the C2–3 level. Osseous lateral mass fusion from C2–6 was also present (Fig. 1C and D). Magnetic resonance imaging showed significant narrowing of the spinal cord at the C3–4 level as well (Fig. 1E and F).

Operation. The patient was admitted to the hospital and a Halo ring was applied. She was placed in traction in the intensive care unit with increasing weight added to the traction. No significant amount of correction was achieved using weight up to 40 lbs. The patient’s neck was placed in an extension position with traction in the operating room. Fiberoptic nasotracheal intubation was used while the patient was awake. Anesthesia was induced using 0.5 minimal alveolar concentration and narcotic intravenous drip. No paralytics were used. Neurophysiological monitoring of the patient’s motor evoked potentials and somatosensory evoked potentials was used during the entire operation.

An oblique incision was used and the spine was exposed in a subperiosteal fashion from C-2 to C-7. The C3–4 plate and interbody graft were removed. Cervical corpectomies of C-3, C-4, C-5, and C-6 were then performed using rongeurs and a high-speed drill. The lateral edges of the vertebral bodies were left in place. The transverse foramina were then identified underneath the transverse processes bilaterally. Anterior transverse foramina were removed using a Kerrison rongeur. The VAs were skeletonized, which allowed them to be retracted laterally to access the lateral mass from the anterior approach (Fig. 2). Because 4 vertebral bodies were removed and the VA was released through this entire length of exposure, significant lateral mobilization could be achieved, particularly on the concave side. Osteotomies were performed at the C3–7 level laterally to the extent of the longus colli. A Midas Rex bur and a small osteotome were positioned between the pedicles and nerve roots and used to release the lateral masses from the anterior aspect. It should be noted that once the spinal cord and nerves are identified and protected there are no vital structures deep (dorsal) to the lateral masses.

After release of the vertebral bodies and lateral mass fusion, additional traction was then carefully added and the cervical kyphosis was corrected. A titanium cervical cage was then placed between C-2 and C-7. A buttress plate was also placed at the C-7 level. A buttress plate was used to allow further posterior compression and to maintain some mobility for further deformity correction posteriorly. At this point, significant correction of the deformity was achieved (Fig. 3A and B). The total operative time for the anterior procedure was 5.5 hours.

The patient was taken to the intensive care unit and remained intubated after the anterior procedure. She was

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brought back to the operating room 3 days later for the posterior part of the operation. She was first placed in a Mayfield head holder in the prone position. The cervical spine was exposed from the occiput to T-3. The right lateral mass of C-3 and C-4 were noted to be absent, probably from prior surgery. Pedicle screws were placed at T-1, T-2, and T-3. Then an occiput plate, C-1 lateral mass screws, and C-2 pedicle screws were placed. The old C3–4 hardware on the left side was removed. Lateral mass screws were then placed on the left side of C-3 and C-4, as well as C-5, C-6, and C-7 bilaterally. Additional translation was achieved by moving the Mayfield head holder. Rods contoured to the spine were then placed and locked into place with locking nuts and 3 crosslinks (Fig. 3C and D).

Postoperative Course. Excellent correction of the kyphosis and scoliosis was achieved. Her kyphotic deformity improved from a 75° kyphosis to neutral (Fig. 3C and D). Her scoliosis improved from 75° to 18° scoliosis to the right (Fig. 3C and D). Clinically, she also improved significantly. Her right proximal upper extremity motor strength (deltoid, biceps, and triceps muscles) improved from 1/5 to 3/5, and her right grip improved from 2/5 to 3/5. Her right lower extremity improved from 2/5 to 3/5. Her left-side strength remained stable. She had no signs of Horner syndrome.

Because of her multiple medical comorbidities, including chronic obstructive pulmonary disease, coronary artery disease, and congestive heart failure, she had a prolonged hospital stay after the operation. She developed chronic pulmonary infiltrates and respiratory failure. She eventually required a tracheostomy and was weaned off the ventilator over the course of 4 weeks. Despite these medical complications, her neurological functions remained stable. She was transferred to an outpatient rehabilitation center, and the cannula was removed from her trachea. She was maintained in a halo vest for 2 months. At her 3-month postoperative visit, alignment of her cervical spine remained stable (Fig. 3E and F). Although postoperatively the patient was maintained on tube feedings for nutritional reasons and dysphagia, her swallowing function returned to baseline levels prior to discharge from the rehabilitation facility. Her voice was normal at the 3-month follow-up visit. She continued to improve neurologically with physical therapy. The patient was noncompliant and did not return for her 6-
month follow-up visit because she was out of the area, but reported (by phone) continued neurological improvement and minimal neck pain. Postoperative radiographs of the patient at 3 months after the halo had been removed demonstrated no change in alignment or loosening of the instrumentation.

The patient died 11 months postoperatively due to progression of congestive cardiac failure. The patient’s husband reported during a follow-up call that the patient had continued to have good neurological function, was able to maintain her head position, and was very satisfied with her procedure.

Discussion

Surgical indications for kyphosis generally include neurological deficits, functional disability (such as forward gaze, swallowing), severe pain that is refractory to conservative treatment, and progression of the kyphotic deformity. Multiple approaches are available to correct cervical kyphotic deformity, and can be divided into anterior, posterior, and a combination of the two. The choice of surgical approach is dependent on whether the cervical spine is flexible or rigid and whether the facets are fused or not. In the case of a flexible cervical kyphotic deformity and no significant cord compression anteriorly, posterior correction and fixation may be sufficient.1,2 Posterior fixation is achieved using either pedicle screws or lateral mass screws with rods. If the patient’s head is fixed in a Mayfield headholder or halo ring, its position can be adjusted carefully to achieve the desirable lordosis. Alternatively, serial compressive force can be applied to the screws of a rod/screw fixation system to achieve the correction using facet osteotomy. Correction of the deformity is a result of shortening of the posterior column through compression and lengthening of the anterior column.3 Neuromonitoring can be used to monitor the process and avoid overcorrection.

Although posterior fixation and correction are easy to perform and probably have fewer complications, it often is not always sufficient to indirectly relieve anterior compression. Anterior decompression, correction, and fixation can be used in these cases. Anterior decompression is achieved by a combination of discectomy and corpectomy.8,15–17 After discectomy and/or corpectomy, distraction posts are then used to provide segmental extension, which results in lordosis.9 Importantly, this reduction in deformity is only possible if the facet joints are not fused. The anterior cervical spine is then reconstructed using a strut graft, titanium cage, or polyetheretherketone cage. For interbody grafts, lordotic grafts should be used. An anterior cervical plate can then be used to hold the implants in place. Anterior fixation and correction are sometimes supplemented by posterior fixation. Additional correction can be achieved by supplementary posterior fixation and correction with shortening of the posterior column.1 In addition, this also adds significant strength to the overall construct, thus reducing the chance of pseudarthrosis and construct failure.13

In some cases, the cervical deformity is fixed due to fused anterior and posterior elements. In these cases, release of both sides is necessary before the correction of the
deformity. In most cases, both anterior and posterior fixations are needed. Then, a 540° procedure is necessary.\textsuperscript{1,14,15} For example, anterior release and decompression are performed first, followed by posterior release and fixation. Correction of deformity takes place after both sides are released. Graft and fixation are then placed anteriorly as the last stage of the procedure. In these cases, the patients have to be turned from supine to prone, then from prone to supine. Between the first and second stages, anterior release and decompression would already have been completed but fixation/instrumentation would not yet have been performed. Although the risk of turning a patient with an unstable spine from supine to prone is mitigated by applying a halo vest or special frames, the potential of injuring the spinal cord exists nevertheless.

The described technique is for fixed kyphosis that only involves a fixed anterior and posterior column over several segments and should only be attempted by surgeons experienced in VA mobilization and in anterior osteotomy procedures for a fixed cervical deformity. The technique developed from our experience in performing VA identification and mobilization for cervical spondylectomy and anterior cervical releasing osteotomy. We noted in several cases that it was possible—without significant lateral artery retraction—to access the ventral aspect of the cervical facets between the nerve roots and pedicles once the VA was released over at least 2 levels from the transverse foramen anteriorly. In this type of case we would normally identify the VA and mobilize it laterally to protect it during drilling of the lateral vertebral body and osteophytes.

Anterior VA mobilization during cervical surgery is not new and has been shown to be reasonably safe during anterior cervical foraminotomy and corpectomy.\textsuperscript{6,9,10} During the anterior osteophyte release we greatly prefer to identify the arteries first rather than tediously drilling near them from the inside out. We believe this is faster and safer because a Penfield dissector can then be inserted to protect them and, if an injury occurs, the artery is already exposed for proximal and distal control and repair. If a hole is made in the artery using the inside-out drilling technique, proximal control is not present. Although we have not injured the artery by mobilizing it in this fashion, we have injured the vessel in surgery for tumors in this area and have repaired it by direct suture repair and by suturing a small muscle patch from the longus colli over the area. We routinely obtain postoperative angiograms in all cases of VA injury to rule out dissection or pseudoaneurysm formation.

The incidence rate of Horner syndrome in anterior cervi-
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cal surgery has been reported to be 0.2–4%. The sympathetic chain is, on average, 1 cm from the medial border of the sternocleidomastoid muscle but becomes more medial in the lower cervical spine. Although, theoretically, with increased lateral longus colli mobilization the risk of Horner syndrome might be expected to increase, we did not experience this complication in this case. Cornelius and colleagues have also recently reported a 0% incidence of Horner syndrome in their case series of 40 anterior cervical foraminotomies, despite the use of a transverse longus colli incision over the cervical transverse process to expose the VA. In our technique we mobilize the longus longitudinally over multiple segments and avoid sectioning it in the transverse plane. We did inform our patient of the potential complication of Horner syndrome before the operation.

Our technique allows us to perform both anterior and posterior release through the anterior approach. Correction of the kyphosis and reconstruction of the anterior column are also performed during this stage. The patient then can undergo posterior fixation at the second stage of surgery. At this point, the patient’s spine has been well decompressed and reconstructed anteriorly.

Conclusions

We described in this paper a novel technique of performing anterior and posterior release through an anterior approach. This approach allows correction of fixed cervical kyphotic deformity and circumferential fixation in a 2-stage procedure rather than in a 3-stage (540°) procedure. This technique should only be considered in cases of a circumferentially rigid deformity in which an anterior releasing osteotomy over several levels would be required anyway and should only be utilized by surgeons experienced in surgery around the VA. Although this technique does involve risk of VA injury, we wish to emphasize that this risk occurs in all cases in which anterior cervical releasing osteotomies are performed. We do not feel that this risk is increased by the small amount of additional lateral retraction needed to access the facets. More cases and experience will be necessary to determine the ultimate safety and utility of the technique we describe.

Disclaimer

None of the authors has any financial interest in the subject under discussion in this paper.

References


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